HIGHWAY DESIGN	Chapter GEOMETRIC DESIGN GUIDELINES Subject Introduction

INTENT OF USE: This chapter includes geometric design guidelines that are commonly used by the Kentucky Transportation Cabinet. Unless otherwise stated, it is not intended that these guidelines be mandatory. These guidelines are intended to provide safety, operation efficiency, convenience and environmental quality. AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*** and engineering judgement should be used in the design process. This manual should not supersede the application of sound engineering principles by experienced design professionals.

There is an increased emphasis on the involvement of the public and local communities in our decision-making process. Situations will arise that require increased flexibility in the design process. Goals of the local community, such as environmental quality, aesthetics, historic preservation, etc., as well as goals of the Cabinet need to be addressed.

This document is not intended to address those unique cases where one-lane facilities are considered. All criteria developed for those cases shall be considered as design exceptions and documented accordingly.

CHAPTER TOPICS: The following pages contain information on the Primary Design Elements, General Design Considerations, and the Design Exception Process. Also included is design guidance for Truck Climbing Lanes and Emergency Escape Ramps. At the end of the chapter are the Kentucky "Common Geometric Practices" sheets and some example typical sections that may be used for reference during the design process.

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HIGHWAY DESIGN	Chapter GEOMETRIC DESIGN GUIDELINES
	Subject Primary Design Elements

Summary: This section includes several elements that are typically used in highway design including sight distance, horizontal alignments, vertical alignments, and cross sections. Each of these elements is important in the development of a highway design project and is further explained in AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition.***

SIGHT DISTANCE: Sight distance is the length of highway that is visible ahead of the driver. In highway design, there are three types of sight distance to consider: stopping sight distance, decision sight distance, and passing sight distance. Consult Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*** for methods used to compute these distances. For information concerning Intersection Sight Distance, see Chapter HD-1000 of this Manual.

- Stopping Sight Distance - Stopping sight distance is the distance that is required for a vehicle traveling at or near the design speed to stop safely. It is the sum of two components: brake reaction time and braking distance. In computing and measuring stopping sight distance, the height of the drivers' eye is estimated to be 3.5 feet and the object height is 2.0 feet.

- Decision Sight Distance – There are cases when stopping sight distance is not sufficient for the driver to avoid unforeseen or unusual occurrences. Typical examples of such occurrences are lane drops, areas of high traffic concentration, and traffic control devices. Under these circumstances, it is recommended that the designer take into consideration decision sight distance. Decision sight distance is the distance required for the driver to detect an unexpected or unusual occurrence, recognize it as a hazard, and initiate and complete a maneuver that will allow the driver to safely and efficiently avoid the hazard. Decision sight distance is based on the same criteria of drivers' eye height and object height as stopping sight distance.

- Passing Sight Distance – Passing sight distance is the distance required for a vehicle to safely and successfully pass another vehicle, typically on a two-lane highway. Adequate horizontal and vertical sight distance for passing should be provided frequently. In computing and measuring passing sight distance, the height of the drivers' eye is estimated to be 3.5 feet and the object height, which is based on average vehicle height, is 3.5 feet.

Another definition of passing sight distance relates to the level of service and design capacity concepts. Refer to the ***Highway Capacity Manual*** for a more complete discussion of passing sight distance. (HCM-Chapter 8)

HORIZONTAL ALIGNMENT: Several components comprise the horizontal alignment design of a highway, including tangents, circular curves and, in many cases, spirals. Safety, existing conditions, environmental considerations, economics, and highway classifications influence the horizontal alignment.

CIRCULAR HORIZONTAL CURVES: Circular curves enable a change in direction of the roadway. The minimum radius of curve that can be used for a given design speed is shown in Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition***. The laws of mechanics that govern vehicle operation on curves, such as friction factors, speed, and the amount of superelevation, help to establish this minimum. Although the minimum radius is allowable, the designer should strive to exceed it.

If compound curves are used on the mainline, the radius of the flatter curve shall not be more than 1.5 times greater than the radius of the adjacent sharper curve. It is preferable to avoid compound curves. For interchange ramp design see Chapter HD-1000 on Intersections of this guide.

Horizontal curves in the same direction separated only by a short length of tangent ("broken-back" curves) and horizontal curves in the opposite direction separated by a short tangent (reverse curves) should be avoided. Generally it is preferable to use flatter curves connected by transition curves.

SPIRAL TRANSITION CURVES:

On highways with design speed of 45 m.p.h. and greater a motor vehicle does not follow a path that is parallel to the centerline of the road when traveling from a tangent section into a horizontal curve, or vice versa. This steering change cannot be adjusted instantly. Therefore, to make this transition from tangent to curve as smooth as possible, it is recommended to use spiral curves when superelevation rates are 3.0 percent or greater. A spiral curve is a curve with a variable radius. As discussed in the next section, the minimum length of runoff (L) values shown in Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*** can be used to determine the minimum length of spiral for the transition curve. The lengths can be rounded up to even lengths that facilitate simpler calculations.

Advantages of using spiral curves include:

- Spirals provide a natural path for drivers and minimized encroachment on adjoining traffic lanes.
- Spirals provide a place to transition superelevation runoff.
- Spirals facilitate pavement widening through a curve.
- Spirals enhance the appearance of a highway.

For interchange ramp design see Chapter HD-1000 of this Manual.

SUPERELEVATION:

Maximum rates of superelevation considered for use on roadways are controlled by the following factors: climate conditions (snow and ice occurrences), terrain (flat, rolling or mountainous), urban or rural facilities, and amount of slow-moving traffic. In general, use a maximum rate of 8.0 percent on rural roadways due to Kentucky's snow and ice frequencies. It is also recommended that a maximum rate between 4.0 percent and 6.0 percent be utilized in urban areas, especially on low speed, high volume facilities. Refer to the superelevation tables in Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*** to determine the amount of superelevation to use for a given design speed and radius of curvature. It is ultimately up to the Project Engineer and the Project Team to decide on a project-by-project basis which values will best suit the conditions of the facility.

When spirals are utilized, the superelevation runoff distance (L) should be the same as the length of spiral. If spirals are not used, the minimum runoff lengths can be seen in Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition***. Divide the transitions between the tangent section and the curve as follows: locate 2/3 of L on the tangent section and extend 1/3 of L onto the horizontal curve. The P.C. will be the control for this situation and will apply to both ends of the curve.

Once the spiral (runoff) length (L) is determined, the tangent runout can be calculated. The runout (R) is the transition from a normal crown section to a section in which the outside lane(s) are rotated to a flat section. The formula for this transition length is:

$$R = \frac{Lc}{e}$$

Where: R = Runout length
L = Length of spiral or length of runoff,
c = Normal rate of pavement crown (commonly 2.0 percent), and
e = Superelevation rate.

Once the roadway is transitioned to this flat section, the template is rotated to full super utilizing the runoff (L) as the transition length. Note that the inside lane(s) do not begin to rotate until the outside lane(s) exceed the normal cross-slope of the inside lane(s). At this point, both inside and outside lanes rotate together to full super.

After the normal shoulder cross-slope is exceeded, the full width of the inside shoulder is rotated to match the roadway superelevation. For shoulder widths less than or equal to 4 ft, the full width of the outside shoulder is rotated to match the roadway superelevation. If the shoulder width is greater than 4 ft, a portion of the outside shoulder, the shoulder on the high side, is not superelevated to match the mainline rate. The non-superelevated shoulder remains sloped away from the roadway. For shoulder widths greater than 4 ft and less than or equal to 6 ft, the non-superelevated shoulder width will be 2 ft. For shoulder widths greater than 6 ft, the shoulder “break” is to occur at the midpoint of the shoulder width. This requirement may not have application to inside shoulders of median sections and multilane facilities. For the “roll-over” between superable and nonsuperable shoulder, the algebraic difference in rate of cross-slope is not to exceed 12.0 percent.

Refer to Standard Drawing Nos. RGS-001 and RGS-002 current edition for the accepted method of attaining superelevation.

Superelevate truck climbing lanes and auxiliary lanes at the same rate as the adjacent through lanes.

Obtain written approval from the Director, Division of Bridge Design, and the Director, Division of Highway Design before developing plans for an alignment that requires a bridge superelevation rate greater than 6.0 percent.

PAVEMENT WIDENING ON CURVES:

Offtracking is common to all vehicle types. When traversing a horizontal curve, the rear wheels of a motor vehicle track inside the front wheels and it is difficult for a driver to hold his vehicle in the center of the lane. These problems become more pronounced when lane widths are narrow and curves are sharp.

A common practice to help offset these conditions is to widen pavements on horizontal curves. Since widening is costly and little is gained from a small amount of widening, a minimum of 2 feet should be used.

Reference should be made to Standard Drawing No. RGS-00l current edition and to Chapter 3 of AASHTO'S ***A Policy on Geometric Design of Highways and Streets, current edition***, to determine the amount of widening to be used for a particular radius of curve. When spiral transition curves are used, equally divide the widening between the inside and outside edges of pavement. The widening should transition from zero at the tangent to spiral (T.S.) to full widening at the spiral to curve (S.C.).

When spiral transition curves are not used, do all the widening on the inside edge of pavement. The widening should transition from zero at the beginning of the tangent runoff (L) to full widening at the point of full superelevation. Transition ends should avoid an angular break at the edge of pavement.

HORIZONTAL SIGHT DISTANCE:

The sight distance of a horizontal curve is measured along the centerline of the inside lane of the curve. In some cases, objects such as cut slopes, vegetation, buildings, etc obstruct the sight distance. When designing the horizontal alignment, the designer should check in obtaining adequate sight distance on horizontal curves. In some instances, additional right-of-way may be required.

For horizontal curves, consider both stopping sight distance and passing sight distance. Passing sight distance is recommended for consideration only on tangents and very flat curves. Sight distance restrictions on sharper curves makes this consideration prohibitive. Horizontal sight distance is to be coordinated with the vertical sight distance discussed in the following section of this manual.

An additional subject to consider is intersection sight distance in roadway design for roads with at-grade intersections. Refer to

Chapter HD-1000 on Intersections, and AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*****.**

VERTICAL ALIGNMENT: The terrain of the traversed land influences the design of the roadway. Terrain is generally classified into 3 categories: level, rolling, and mountainous. As with the horizontal alignment, the vertical alignment is made up of tangent sections and curves.

GRADES: The design speed and type of terrain establishes the maximum suggested grades. The suggested maximum grades can be seen in Exhibits 500-01, 500-02, 500-03, and 500-04 of this manual. Also considered in the design process are the types of vehicles that are expected on the roadway. The effect of grade on truck speeds is far more pronounced than on the speeds of passenger cars. In addition to the grade, the length of grade is also very important to consider. Look at Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*** to determine critical lengths of grade.

AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*** suggests a maximum grade of 5 percent for a design speed of 70 mph and 7 to 12 percent for a design speed of 30 mph. The maximum design grade should not be considered the desirable grade to achieve on a roadway. Where feasible, it is recommended that grades be less than the maximum allowable. However, grades less than 500 feet in length and one-way downgrades may be approximately 1 percent steeper than the maximum. This may be increased to 2 percent if it is on a low volume rural highway. Steeper grades may also be used where extremely high construction costs would be encountered due to flatter grades. Care should be taken when increasing grade in rural areas because it may introduce the need for truck climbing lanes. The use of steeper grades than the maximum should be discussed by the project team and documented in the Preliminary Line and Grade Report and the Design Executive Summary.

It is necessary to maintain a minimum grade in order to provide adequate drainage. Level grades can be used on uncurbed, non-superelevated roadways as long as there is an adequate crown. It is recommended that curbed roadways maintain a minimum grade of 0.50 percent. A grade of 0.30 percent may be considered if there is a high-type, adequately crowned pavement .

The maximum suggested grades for entrances are shown in Standard Drawing No. RPM-110 current edition.

VERTICAL CURVES:

The introduction of vertical curves effects the transition from one rate of grade to another and usually consists of a parabolic curve. Vertical curves are either the crest or sag type depending on the positive/negative slopes of the intersecting grades. Refer to any standard route-surveying textbooks for details on the method of calculating vertical curves.

A common means to determine the minimum length of curve needed for various design speeds is K, the rate of curvature. K is defined as the length of vertical curve divided by the algebraic difference in grades (L/A). K is the horizontal distance required to effect a 1 percent change in gradient.

The minimum length of vertical curve (L) can be calculated after K is found in Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition.*** Suggested lengths of vertical curve for a given design speed are based on sight distance for crest vertical curves and on headlight sight distance for sag vertical curves.

In addition to sight distance, the designer should also consider riding comfort and appearance when selecting a length of vertical curve. Long curves give a more pleasing appearance and provide a smoother ride than short vertical curves.

SIGHT DISTANCE: The design of both crest and sag vertical curves are dependent on stopping sight distance calculations.

- Crest Vertical Curves - For crest vertical curves, base the stopping sight distance on a height of eye of 3.5 feet and a height of object of 2.0 feet.

- Sag Vertical Curves - For sag curves, base the stopping sight distance on a 2.0 feet headlight height and a 1^{o} angle of light spread upward from the headlight beam.

The stopping sight distance values for various design speeds listed in Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*** should be minimum values. Generally it is not practical to design crest vertical curves to provide for passing sight distance due to required distances being 7 to 10 times longer than on a tangent or a sag condition. Refer to Chapter 3 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*** for stopping sight distance design controls.

CROSS-SECTIONS: To determine the typical cross-section for a given highway, use four basic design controls:

- Functional Classification
- Area (Rural or Urban)
- Volume of traffic
- Design speed

The context of the project (Environmental, Right of Way, Utilities, Pedestrians, and other considerations) may affect selection of the typical cross-sections.

Use the Common Geometric Practices (Exhibits 500-01 through 500-04 of this manual) with the approved geometric design to determine the typical cross-section. Exhibits 500-05, 500-06, and 500-07 show example typical sections. Cross-section items include the following: pavement slope and width, shoulder width and slope, curb placement, and typical earth slopes in cuts and fills.

Traveled ways located in tangent sections usually have a crown or high point located in the center and a cross-slope down to the edges of pavement. Divided, multilane highways may be crowned separately as a two-lane highway, or they may have a unidirectional cross-slope across the entire width of traveled way. The rate of cross-slope is important. Steep slopes minimize ponding of water, but they may be uncomfortable to the driver. It is recommended that the cross-slope range from 1.5 to 2.0 percent.

Roadway lane widths affect the comfort and safety of driving. Generally, 12-ft lanes are suggested. Refer to Chapter 4 of AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition***.

The shoulder of a roadway is adjacent to the traveled way and is used for stopped vehicles and lateral support of subbase, base and surface courses. Shoulders can also be used to avoid potential crashes, to improve sight distance, to provide driver comfort, to improve highway capacity, to provide lateral clearance for signs and guardrail, and to provide space for pedestrians and bicyclists. Shoulders range from 2-ft earth shoulders on minor rural roads to 12-ft paved shoulders on major roadways. Contrary to AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition*** definitions on shoulder widths, Kentucky's definitions are as follows:

- Graded or Full Shoulder – the distance from the edge of travel lane to slope break.
- Usable Shoulder – the clear area between the traveled way and any barrier or break point. Typically this distance is the same as the Graded or Full Shoulder when barriers are not present.
- Paved Shoulder – the width of shoulder paving, which may be constructed up to any portion of the shoulder within 1 foot of the slope break or to the face of the barrier.

**Unless otherwise specified, references to "shoulder" in this document shall mean "Graded or Full Shoulder."

The minimum inside Full Shoulder width is 6 feet on four-lane divided highways. For six or more lanes, the inside shoulder shall be the same as that determined for the outside shoulder. Any exceptions will be documented in the Design Executive Summary. See Design Exception process at the end of this chapter for more information.

Curbs are often used on low speed urban highways. In this situation it is preferable to offset the curb 1 to 2 ft from the edge of traveled way. If curbs are utilized on high-speed rural highways, locate them outside the edge of the shoulder. It is recommended that vertical curbs utilized along the outside edge of the shoulder of a high-speed facility be of the mountable type and be limited to a 4-inch vertical height. This is especially important if the curb is being utilized in conjunction with other types of traffic barriers.

Ditches and embankment slopes are not a geometric design element and therefore are not subject to the Design Exception Process. Roadside ditches should be evaluated based on their ability to function hydraulically. The choice of fill slopes as well as ditch configurations should always take into account their effect on roadside safety. Generally, fills lower than 10 feet should be 4:1 and fills higher than 10 feet should be 2:1 with adequate protection. The ***AASHTO Roadside Design Guide*** defines 4:1 slopes as recoverable, 3:1 slopes as traversable, and steeper than 3:1 is considered a hazard. Please refer to the HD-900, the Roadside Design Chapter, and ***AASHTO Roadside Design Guide*** for further information.

The Project Manager in concert with the Project Team will determine the level of geotechnical investigation required. Typically this will vary from advisory to full-scale geotechnical analysis. Generally when embankments are to be constructed over existing ground slopes of 15% or greater, Embankment Foundation Benches shall be constructed in the existing slopes. Please refer to the **KYTC Standard Drawing**, **current edition**, for specific details. Ditch Benching and Overburden and/or Weathered Zone Benching Details are outlined in the **KYTC Geotechnical Manual**.

MEDIANS: A median is the portion of a highway separating opposing directions of the traveled way. The median width is defined as the dimension between the edges of the traveled way and includes any left shoulders. It has been demonstrated that there is a benefit in any type of traffic separation on multi-lane facilities, whether it be raised or flushed. Wider medians are desirable at rural, unsignalized intersections, however, at urban/suburban signalized intersections, medians wider than 60 feet may lead to inefficient signal operation. Further detailed information on median design can be found in Chapter 4 of ***AASHTO's A Policy on Geometric Design of Highways and Streets**,* current edition*.*

Below are some of the various functions of medians:

- Separate opposing traffic flow,
- Provide a recovery area for out-of-control vehicles,
- Provide a stopping area in case of emergencies,
- Minimize headlight glare from on-coming vehicles,
- Provide width for future turn lanes,
- Provide storage for left turning or crossing vehicles from an approach road,
- Open green space (urban areas),
- Refuge for pedestrians (urban areas), and
- Control of left-turning/U-Turning movements.

TYPES OF MEDIANS*:*

There are three types of medians: depressed, flush, and raised. The context of the project (environmental, maintenance, right of way, utilities, pedestrians, cost, and other considerations) will affect selection of the median type. Described below are the different types of medians.

Depressed Medians: Depressed medians provide traffic separation, accommodate roadway drainage, facilitate maintenance activities, and provide storage for snow and ice removal. Depressed medians are generally utilized in areas where there is sufficient right of way available, where the need for constructed median crossovers are relatively few and where the roadway has either partially or fully controlled access. A depressed median can also be used with partial control facilities where access is fairly limited or is restricted to right turns in and out with exception of specific median crossover locations. The median side-slopes and any drainage structures located within the median area should follow the recommendations of ***AASHTO's Roadside Design Guide,*** current edition. Depressed medians should have a minimum width of 40 feet.

Flush Medians: Flush medians provide traffic separation, accommodate traffic movement, facilitate maintenance activities, and provide storage for snow and ice removal. Flush medians are generally utilized on urban facilities with widths varying from 4' min.-16' max. Common practice has been to use 12' – 14' flush median when utilized as a TWLTL. The median should be crowned or depressed for drainage. Flush medians should be delineated according to guidance found in the ***M.U.T.C.D.***, current edition.

It should be noted that flush medians and two-way left-turn lanes (TWLTL) have different functional characteristics and should be addressed accordingly. The TWLTL operation may be appropriate where the speed on the roadway is relatively low (45 mph or less) and there are no heavy concentrations of left-turning traffic. TWLTLs should be striped according to guidance found in the ***M.U.T.C.D.***, current edition.

Raised Medians: There are three types of raised medians:

Mountable – Mountable medians may be utilized to address channelization, clear zone, aesthetics, or drainage issues. Please refer to the ***KYTC Standard Drawings*** *RPM-011, RPM-012, & RPM-015* for specific details of mountable medians.

Non-Mountable Medians – Non-mountable medians (barrier medians) typically may be utilized to address traffic separation, pedestrian havens, channelization, or access management. Barrier medians typically use curbs to separate the median from the traveled way. For details see ***KYTC Standard Drawing*** *RPM-010.* When used in close proximity to traffic, barrier medians may create safety concerns at higher speeds and should be considered in context to other project design elements and costs.

Median Barriers – Median barriers typically may be utilized in high-speed applications to address traffic separation and channelization. Median Barriers are detailed in the ***KYTC Standard Drawings*** *RBM-001, RBM-003, RBM-006, RBM-050,* and *RBM-053*. Please refer to ***AASHTO's Roadside Design Guide****,* current edition, for use and placement of Median Barriers.

CROSSOVERS:

Emergency/Maintenance crossovers are breaks in the median to allow emergency and maintenance traffic to cross. To avoid extreme adverse travel for emergency, law-enforcement and maintenance vehicles, emergency/maintenance crossovers on rural freeways are normally provided where interchange spacing exceeds 5 miles. Care should be taken in the design of these to ensure they do not present an undue hazard to the through traffic. For design details, refer to the Intersection Chapter of ***AASHTO's A Policy on Geometric Design of Highways and Streets,*** current edition.

BRIDGE WIDTHS

The Usable Shoulder width shall be maintained across bridges. Any exceptions will be documented in the Design Executive Summary. The minimum width of a bridge on a two-lane bi-directional roadway is 22 feet. For roads with ADT<400, refer to **AASHTO's *Geometric Design Guidelines for Very Low-Volume Local Roads (ADT≤ 400)***.

A 6-foot minimum inside shoulder is required across bridges on four-lane divided highways. This means that the inside shoulder on the roadway must be widened near the bridge end to accommodate barriers (see Standard Drawing No. RBB-002 current edition). The outside shoulder on the bridge will be the same width as the roadway shoulder to the face of the barrier.

For other bridge geometric design issues refer to the Bridge Design Manual.

HIGHWAY DESIGN	Chapter GEOMETRIC DESIGN GUIDELINES
	Subject General Design Considerations

Summary: This section includes factors that are important in the design process. The criteria differ for each functional classification of roadway. The suggested design criteria for each classification can be found in AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition.***

DESIGN CONSIDERATIONS:

For any highway project, the design controls and design criteria establishes the minimum values to use for the primary elements of a particular highway. Design controls and design criteria normally considered in the design of a highway are:

- Functional classification
- Area (urban or rural)
- Volume of traffic (DHV and ADT)
- Percentage of trucks
- Design speed
- Topography (flat, rolling, or mountainous terrain)
- Level of service (for more information see chapter 2 in AASHTO's ***A Policy on Geometric Design of Highways and Streets, current edition***)
- Environment
- Other modes of transportation (bicycles, pedestrians, etc.)
- Special considerations such as the length of project, the condition of roads in the vicinity of the project, and the likelihood of adjoining segments being improved in the foreseeable future.

In the early stages of a project, a Design Executive Summary, TC 61-9, is approved by the Director, Division of Highway Design. This form specifies the values used for the design criteria. See Chapter HD-300 of this manual for more specific information on DES submittal.

There are other factors to consider during the design process. The following are suggestions that promote good design practices:

- Do not design horizontal and vertical alignments independent of each other. The coordination of these elements should begin early in the design process.
- Create alignments consistent with the existing topography and preserving property and community values.
- A flowing line that conforms generally to the natural topography is preferable to one with long tangent sections that cuts through the terrain.
- Attempt to utilize flat curves with radii greater than the suggested minimum values, using the suggested minimums for the most difficult conditions.
- An alignment should be as consistent as possible. If possible, avoid introducing sharp curves at the end of long tangents. Also, if possible, avoid sudden shifts from flat curvature to sharp curvature.
- Vertical curves which fall within the limits of horizontal curves or vice versa, generally results in a more pleasant roadway facility.
- Create horizontal and vertical alignments to be as straight and flat as practical at intersections due to the need to provide appropriate sight distance along both intersecting roadways.
- Do not automatically utilize the minimum suggested values for design.

ROADWAY CLASSIFICATION:

The "Functional Classification" of a roadway is the grouping together of roadways by the type of service they provide based upon land use and type of traffic being generated along a corridor. This classification has been developed as a means of communication within the Transportation industry. The determination of a facilities functional classification is one of the first steps in the design process. It should be noted that over a period of time the functional classification of a highway can change depending on the intensity of development and the type of traffic being generated by the development of the corridor. The three basic types of functional classifications are:

- **Rural/Urban Arterials -** Arterials provide a high degree of mobility for the longer trip length. Therefore, they may provide a high operating speed and level of service. Since access to abutting property is not their major function, some degree of access control is desirable to enhance mobility. Arterials are discussed in Chapter 7 of **AASHTO's**

A Policy on Geometric Design of Highways and Streets, current edition.

Freeways - A freeway is normally classified as a principal arterial that has unique geometric criteria. Freeways are discussed in Chapter 8 of **AASHTO's *A Policy on Geometric Design of Highways and Streets, current edition.***

- **Rural/Urban Collectors -** Collectors serve a dual function in accommodating the shorter trip and feeding the arterials. They must provide some degree of mobility and serve abutting property. Thus, an intermediate design speed and level of service is appropriate. Collectors are discussed in Chapter 6 of **AASHTO's *A Policy on Geometric Design of Highways and Streets, current edition***

- **Rural/Urban Local Roads and Streets -** Local roads and streets have relatively short trip lengths, and because property access is their main function, there is limited need for mobility or high operating speeds.. Use of a lower design speed and level of service reflect this function. Local roads and streets are discussed in Chapter 5 of **AASHTO's *A Policy on Geometric Design of Highways and Streets, current edition***.

  The geometric design of very low-volume local roads presents a unique challenge: the very low traffic volumes and reduced frequency of crashes make designs normally applied on higher volume roads less cost effective. The guidance by the **AASHTO's *Geometric Design Guidelines for Very Low-Volume Local Roads (ADT≤ 400)*** addresses the unique needs of such roads and the geometric designs appropriate to meet those needs. These guidelines may be used for roadways with ADT $\leq$ 400.

  Please refer to **Chapter 1 of AASHTO's *A Policy on Geometric Design of Highways and Streets, current edition*** for a more detailed discussion of roadway classifications.

HIGHWAY DESIGN	Chapter GEOMETRIC DESIGN GUIDELINES Subject Design Exception Process

Summary: Although the range of values suggested in this design guide and in **AASHTO's *A Policy on Geometric Design of Highways and Streets, current edition*** provide a flexible range of design features, there will be situations in which the use of the minimum suggested criteria would result in unacceptable right-of-way, utility, environmental, and historical impacts plus project costs. For these situations, the design exception process should be utilized to determine and document the reasons or justifications for the exceptions.

CONTROLLING CRITERIA: There are 13 controlling criteria specified by FHWA for NHS routes. These criteria will be used on all projects as a basis for design exceptions. The criteria are as follows:

- Design Speed
- Lane width
- Shoulder width
- Bridge width
- Structural capacity
- Horizontal alignment
- Vertical alignment
- Grade
- Stopping sight distance
- Cross slope
- Superelevation
- Vertical clearance
- Horizontal clearance (not including clear zone)

Exhibits 500-01 through 500-04 represent Kentucky Common Geometric Practices. The values in these exhibits should not be construed as a basis for determining design exceptions. The designer should refer to **AASHTO's *A Policy on Geometric Design of Highways and Streets, current edition*** and **AASHTO's *Geometric Design Guidelines for Very Low-Volume Local Roads (ADT≤400)***.

EXCEPTION PROCESS:

Exceptions to criteria should be identified early in the design process by the project team. Documentation of recommendations and discussions should be included in meeting or inspection reports. Document design exceptions in the Design Executive Summary, with a detailed written discussion of the sound engineering reasoning and justification for the exceptions, when submitted for approval. FHWA must approve exceptions for Interstate projects. See Chapter 300 of this manual for more specific information on DES submittal and approval procedures.

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HIGHWAY DESIGN	Chapter GEOMETRIC DESIGN GUIDELINES Subject Truck Climbing Lanes and Emergency Escape Ramps

Summary: This section contains Geometric Design Guidelines for Truck Climbing Lanes and Emergency Escape Ramps.

TRUCK CLIMBING LANES

Besides being limited to passing sections, heavily loaded vehicles on sufficiently long upgrades adversely effect the safety and operating speed of traffic on two-lane highways. Truck-climbing lanes are commonly included in original construction or added on existing highways as safety and capacity improvement projects. AASHTO's ***A Policy on Geometric Design of Highways and Streets*** **and the** ***Highway Capacity Manual*** contains additional information on truck climbing lanes.

WARRANTS FOR TRUCK CLIMBING LANES:

The following three conditions should be satisfied to justify a climbing lane:

1. Upgrade traffic flow rate more than 200 vehicles per hour.

2. Upgrade truck flow rate more than 20 vehicles per hour.

3. One of the following conditions exists:
   - Expect a 10-mph or greater speed reduction for a typical heavy truck.
   - Level-of-service E or F exists on the grade.
   - A reduction of two or more levels-of-service is experienced when moving from the approach segment to the grade.

However, safety considerations alone may justify the addition of a climbing lane regardless of grade or traffic volumes.

Consider justification for climbing lanes when exceeding the critical length of grade based on a highway capacity analysis.

SHOULDERS ON TRUCK CLIMBING LANES:

Desirably, the shoulder on the outer edge of a climbing lane should be as wide as the shoulder on the normal two-lane section, particularly where there is bicycle traffic. When adding the climbing lane to an existing highway and conditions dictate, a usable shoulder of four foot width or greater is acceptable.

EMERGENCY ESCAPE RAMPS:

On long descending grades, an emergency escape ramp should be considered. The selection of type would be dependent on the existing conditions. Further discussion on selection and methods of design are contained in AASHTO'S ***A Policy on Geometric Design of Highways and Streets*****.**

A variety of factors should be considered in selecting specific sites for an escape ramp on new or existing facilities. Factors that should be considered include topography, length and percent of grade, potential speed, economics, environmental impacts, and crash experience/data.

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